INDOOR AIR QUALITY ASSESSMENT

Granby Fire Department
250 State Street
Granby, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Jonathan Wilk of the Granby Fire Department (GFD), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Granby Fire Station (the firehouse), 250 Main Street, Granby, Massachusetts. On August 27, 2004, a visit to conduct an indoor air quality assessment was made to the firehouse by Michael Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Symptoms related to restroom flooding and vehicle exhaust prompted this assessment.

The firehouse is a section of the Granby Public Works garage (the garage), a one story, cinderblock building constructed during the 1950s-1960s (Picture 1). The garage contains nine vehicle bays. GFD fire and rescue equipment is housed in the three westernmost bays of the garage. GFD offices are located in a space behind the ambulance bay. The GFD offices consist of a command room, day room and restroom. The GFD spaces are heated by a furnace/air handling unit (AHU) located in a basement area below the day room. As reported by GFD staff, the restroom had experienced a substantial plumbing leak causing damage to the restroom floor and a basement storage area adjacent to the AHU room. Windows in the day room are openable. The AHU room is accessible via a bulkhead door (Picture 2) located outdoors at the rear of the building.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor.

Results

The building has an employee population of approximately 2 full time equivalents (FTE) per shift. The tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from the Table 1 that the carbon dioxide levels were below 800 parts per million of air (ppm) in all areas sampled, which indicates adequate air exchange in areas sampled. At the time of this assessment, the engine bay doors and internal office doors were open, which can greatly reduce carbon dioxide levels. The air handling unit located in the basement does not have the capability to introduce outside air or exhaust air from the building; it tempers and *recirculates* air only. Therefore, the sole source of fresh air in the GFD is through open windows or doors. With a lack of fresh air supply or exhaust ventilation, normally occurring pollutants that exist in the interior space can build up and remain inside the building. In addition, no mechanical means to remove carbon monoxide and other products of combustion produced during mechanical/vehicle operations exists. The return vent for the occupied areas is located in close proximity to the interior door that opens to the ambulance bay. In this instance, pollutants produced in the engine bays (e.g., motor engine exhaust) may be drawn into occupied space

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997). For more information concerning carbon dioxide, please see Appendix A.

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings were measured in a range of 77° F to 80° F, which were close to the BEHA recommended comfort range (Please note that all of the garage doors in the building were open with an outdoor temperature of 80° F on the day of this assessment). The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building was below the BEHA recommended comfort range of 40 to 60 percent in all areas sampled on the day of the assessment. Relative humidity measurements ranged from 64 to 70 percent (outdoor measurement 71 percent). These relative humidity levels would be expect to drop once the heating system is activated in cold weather. The sensation of dryness and irritation is common in a low relative humidity environment. For buildings in New England, periods of low relative humidity during the winter are often unavoidable.

Microbial/Moisture Concerns

The GFD has a number of areas that have either water-damage or mold contaminated materials. As reported by GFD staff, the bathroom had flooded from a toilet overflow, which damaged the floor (Picture 3). Water from the restroom flood penetrated through the floor, wetting building components located in the storage area in the basement. The ceiling of the storage appeared to be gypsum wallboard (GW), which had collapsed onto the floor. The water-damaged GW appeared to be mold colonized. If this is the case, water-damaged materials wetted by this leak should be considered as contaminated with sewage. Sewage contaminated materials require special handling and cleaning to prevent the spread of disease to handlers of these materials (CDC, 1994).

The observed water damage is a concern due to the location of the return ventilation duct connected to the AHU. The return vent duct passes through the basement storeroom that experienced water-damage. The seams of this ductwork do not appear to be sealed. Since the interior of a return vent becomes depressurized when the AHU operates, air and pollutants present in the basement can be drawn into the ventilation system, which can then be distributed into occupied areas of the GFD. In addition, an AHU operating under normal conditions should also have an appropriate air filter installed to remove airborne particles from the air stream. The interior of the AHU was examined and no filter was installed within this unit. Therefore, it appears that unfiltered air from the basement is being drawn into the AHU and then distributed into the occupied areas of the GFD when this equipment is activated.

The following are either mold contamination reservoirs or sources of water observed by BEHA staff in the engine bays, GFD occupied areas or the AHU room in the basement.

- The oil tank located in the AHU room. The oil residue top of the tanks is covered with white material that appears to be mold.
- The garage originally had a gutter/downspout system to collect rainwater from the slightly pitched roof. The gutter was removed (Picture 4), which has allowed water to pour over the rear of the building. Rainwater strikes the bulkhead at the base of the wall, allowing for moisture to penetrate into the AHU room through a damaged seal along the bulkhead (Picture 5). This lack of rainwater drainage also allows for water to strike the casing of the window-mounted air conditioner in the day room, resulting in moisture penetration through the window or adjoining cinderblock.
- A make up air vent for the furnace (Picture 2) is located on the exterior wall of the AHU room. This vent allows hot, moist air to penetrate into the AHU room during the summer. This condition allows for the basement floors and adjoining walls to generate condensation. Condensation wets accumulated dirt and other materials in this room, causing mold growth.
- A suspended ceiling is installed in the engine bay. A substantial number of ceiling tiles were either mold colonized (Picture 6) or water-damaged. The source of

water damaging the ceiling tiles appear to be leaks from the roof. When the AHU is operating and exterior door is closed, mold particles/odors can be drawn from the engine bays into the AHU.

Each of these conditions are likely to be either mold colonies or conditions that can lead to fungal growth. Mold can be a source of respiratory irritants and should be removed in a manner consistent with US Environmental Protection Agency guidelines “Mold Remediation in Schools and Commercial Buildings” (US EPA, 2001).

Other Concerns

Under normal conditions, a firehouse can have several sources of environmental pollutants present from the operation of fire vehicles. These sources of pollutants can include:

- Vehicle exhaust containing carbon monoxide and soot;
- Vapors from diesel fuel, motor oil and other vehicle liquids which contain volatile organic compounds;
- Water vapor from drying hose equipment;
- Rubber odors from new vehicle tires; and
- Residues from fires on vehicles, hoses and fire-turnout gear.

Of particular interest is vehicle exhaust. The firehouse is not equipped with a mechanical exhaust system to remove exhaust from the engine bays during vehicle idling. Of note was the presence of heavily blackened fiberglass insulation (Picture 7) located above the fire apparatus. Although it is possible that the material has mold contamination, the pattern of black discoloration observed on the ceiling system insulation suggests periodic and repeated exposure to vehicle exhaust contributing to occupant exposures to contaminants contained within the exhaust (e.g., carbon monoxide). This smoke residue can be a source of irritants associated with vehicle exhaust.

In addition, the Granby Public Works Department (GPWD) possesses a number of vehicles which operate indoors. No mechanical exhaust ventilation system could be identified for the GPWD section of the building. The restroom area in the building is divided in half by a partial wall topped with a screen. BEHA staff noted significant vehicle exhaust odors in the restroom when GPWD operated vehicles in their section of the building.

The installation and use of mechanical exhaust ventilation in the engine bays can create negative air pressure to prevent/limit odor penetration into occupied areas. For garages, the Massachusetts Building Code requires a minimum ventilation rate of 1.5 cubic feet per minute (cfm) per square foot of floor space of fresh outside air (SBBRS, 1997; BOCA, 1993).

Also of note is the location of the oil tank for the furnace that is located in the AHU room. As noted in the mold contamination section of this report, oil residue was observed coating the top surface of this tank, indicating a leak or means for fuel oil-related vapor to escape the tank. Fuel oil contains a number of volatile organic compounds (VOCs) that can be irritating to the eyes, nose and respiratory system. If VOCs are evaporating from the oil tank, these vapors can be entrained into the ventilation system through holes in the return ducts or breaches/seams in the AHU cabinet.

Conclusions/Recommendations

The conditions observed in the GFD are somewhat complicated. The building that houses the GFD was designed as a public works garage, rather than a fire station intended for 24 hour occupancy. The building has been partially retrofitted with a heating system. Because of the design of the heating system and its location, pollutants resulting from the flood of the basement storeroom can be entrained and distributed to occupied areas of the building. These environmental pollutants that can cause symptoms in individuals who occupy the building for extended periods of time.

A decision should be made concerning the mold and possibly sewage contaminated materials stored in this area. GW, boxes, documents and other stored materials will continue to be a source of mold associated particulates. Eliminating pathways for basement air to move into occupied areas alone cannot serve to reduce or eliminate mold growth in these materials. Materials that may have been damaged by water from restroom drainpipes should be considered contaminated by sewage. Sewage contaminated materials require special handling to protect employees from associated diseases/symptoms.

In order to address the conditions listed in this assessment, the recommendations to be made to improve indoor air quality in this building are divided into two categories: recommendations for short-term and long-term corrective measures. The short-term recommendations can be implemented as soon as possible. Long-term solution measures are more complex and will require planning and resources to adequately address the overall indoor air quality concerns within this building.

Short Term Recommendations

1. Water-damaged materials in the basement should be considered contaminated with sewage. Consider consulting a professional flood restoration firm. We strongly advise that untrained individuals /employees avoid contact with any potentially contaminated standing water or materials on the floor of this storeroom.
2. Remove mold colonized and water-damaged ceiling tiles, fiberglass insulation and GW in occupied areas and engine bays.. These materials should be removed in a manner consistent with *Mold Remediation in Schools and Commercial Buildings* published by the US EPA (2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.
3. Clean oil residue from the oil tank and dispose of the materials in a manner consistent with MA Department of Environmental Protection waste management statutes and regulations.
4. Open engine bay/exterior doors during vehicle operation to provide natural ventilation.
5. Remove all blackened fiberglass insulation above the suspended ceiling in the engine bays.
6. Seal all return ductwork and the AHU cabinet with mastic or HVAC foil tape to prevent air entrainment. The remediation of the AHU and return ductwork will

prevent the draw and distribution of basement air and associate odors to occupied floors.

7. Close the door to the GPWD side of the restroom. Ensure the restroom vents are properly connected to ductwork that air exhausts directly from the building .

8. Keep doors to occupied areas of the GFD closed. Install a door sweep on the door threshold and install weather stripping on the doorframe to create an airtight seal.

9. Seal all wall penetrations in the interior wall shared between the GFD engine bays and the GPWD garage to prevent odor/contaminant migration.

10. Install exhaust ventilation fans in the rear walls of the GFD engine bays as well as the GPWD garage to vent exhaust odors from the building. Once installed, operate the vehicle exhaust ventilation system when vehicles are started.

11. Render the window air conditioner installation water tight.

12. Repair the seal on the bulkhead to prevent water penetration into the basement.

13. Install a door to separate the basement storage area from the AHU room.

14. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter

equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

15. Install disposable filters with an increased dust spot efficiency in the AHU. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 % would be sufficient to reduce airborne particulates (MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the AHU by increased resistance. Prior to any increase of filtration, the AHU should be evaluated by a ventilation engineer as to whether the heat pump can maintain function with more efficient filters.

Long Term Recommendations

1. Examine and repair water drainage/integrity of the roof.
    a. Repair the roof surface.
    b. Repair flashing at rear of the roof.
    c. Install gutter/downspout to drain rain from the roof.
2. Once the roof is repaired, replace all missing ceiling tiles and insulation above the suspended ceiling.

3. Consider installing a ventilation system that consists of flexible hoses that attached to fire/rescue apparatus. This type of system mechanically vents vehicle exhaust directly from the engine bays.
4. Consider building a permanent/air tight wall so that the GFD and GPWD restrooms are separated. Install mechanical ventilation that vents each restroom outdoors.
5. Consider moving the oil tank out of the AHU room to prevent VOC entrainment by the AHU.

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Picture 1

Granby Public Works Garage

Picture 2

Make up Air Vent

Bulkhead Leading To AHU Room at Rear of the Building

Picture 3

Water Damaged Floor of GFD Restroom

Picture 4

Roof Edge at Rear of Building with Removed Gutter Downspout

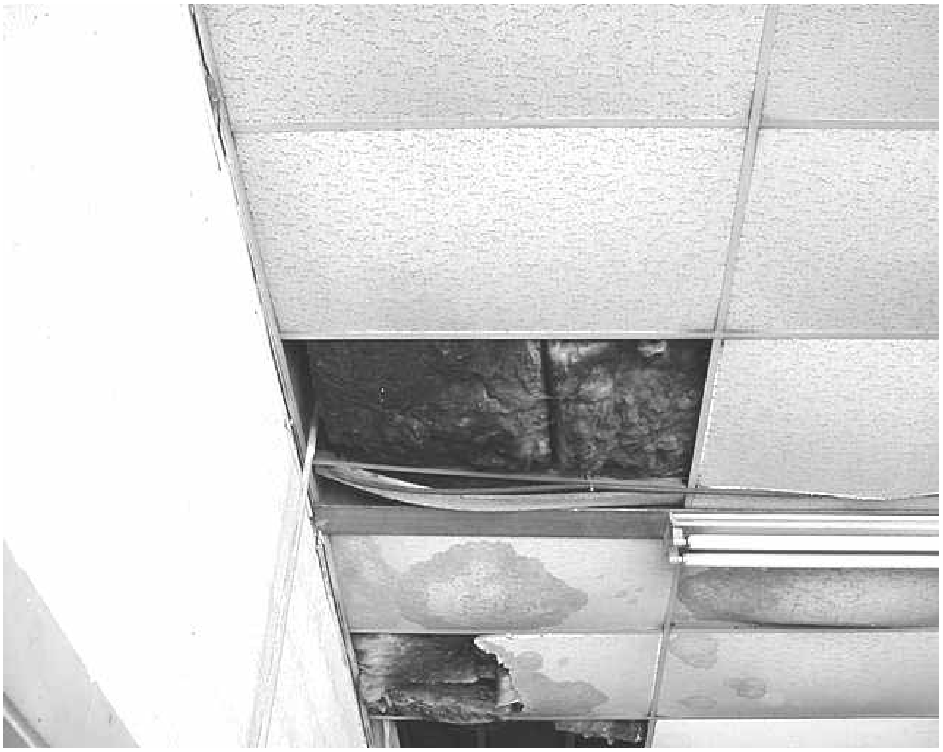
Picture 5

Space between Bulkhead and Exterior Wall

Picture 6

Mold Colonized Ceiling Tile in Engine Bay

Picture 7



Blackened Ceiling Insulation above Fire Apparatus

TABLE 1
Indoor Air Test Results
Granby Fire Station, 250 Main Street, Granby, Massachusetts
August 27, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	420	80	71					Weather: sunny, humid
Engine bay	410	79	69	0	Y	Y	N	• 20+water damaged ceiling tiles • 1 mold colonized ceiling tile • 10+ missing ceiling tiles • blackened fiberglass insulation • outdoor garage door open
Ambulance bay	417	79	68	0	N	Y	N	• bowed ceiling tiles • outdoor garage door open
Day room/kitchen	563	77	70	2	Y	Y	Y	Window-mounted air conditioner Bowed ceiling tiles Door open
Restroom	532	79	66	0	N	N	Y	Half wall/screen Water damaged gypsum wallboard Water damaged floor Door open
Dispatch area	461	80	64	0	N	N	N	Door open
Basement AHU room	642	70	70	0	N	Y	N	Supply is the passive make up air vent for furnace

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%